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January 16, 2004

VIA EMAIL

Mr. Scot Stone
Assistant Chief
Public Safety and Critical Infrastructure Division
Wireless Telecommunications Bureau
Federal Communications Commission
445 12th Street, S.W.
Washington, D.C. 20554

Re: **PR Docket No. 92-257; Amendment of the Commission's Rules Concerning Maritime Communications; EX PARTE PRESENTATION**

Dear Mr. Stone:

As you may recall, on August 29, 2003, our client MariTEL, Inc. ("MariTEL") submitted supplemental comments ("Supplemental Comments") in the above referenced proceeding, responsive to the issues raised in the Fourth Further Notice of Proposed Rule Making ("Fourth Further Notice"). Among other things, the purpose of the Supplemental Comments was to bring to the attention of the Federal Communications Commission ("FCC") the harmful interference that would be caused to MariTEL by the use of channel 87B by automatic identification systems ("AIS"). Attached to those Supplemental Comments were materials presented by MariTEL to the International Association of Lighthouse Authorities ("IALA") demonstrating the interference that would be caused to MariTEL.

As you know, inCode Telecom Group, Inc. ("inCode") has performed a more complete analysis of the effect of AIS operations on channels 87B and 88B. The inCode report has been submitted to the FCC in the context of other proceedings. However, MariTEL wishes to ensure that the results of the inCode report are also taken into consideration in this matter as well. Accordingly, MariTEL hereby submits the inCode report and asks that the FCC consider the results thereof in this proceeding.

Pursuant to the provisions of Section 1.1206(b) of the FCC's rules, a copy of this letter and the accompanying report have been submitted electronically for inclusion in the record of this proceeding. If there are questions concerning this matter, please let me know

Cordially yours,

/s/

Russell H. Fox

Attachment

cc: Marlene H. Dortch, Secretary (electronically)

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The World's Wireless Technology Consultant

Interference Considerations Of Simplex Operation 1371 AIS Technologies With Respect To MariTEL's Spectrum (Updated to Include VHF Data Transmission Devices)

Prepared for: MariTEL, Inc.

Originally Prepared on: October 9, 2003

Revised on: January 14, 2004

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Section 1.0: Objective

This report will encapsulate the results of tests performed by inCode from August 28th through September 12th (analog VHF Public Coast (VPC) device) and additional tests performed from December 11th through December 31st (digital VPC device) on behalf of MariTEL, Inc (MariTEL) to investigate the potential interference between ITU-R 1371-1 AIS technologies and MariTEL's VPC spectrum. *This report has updated results and findings from the previous October 9, 2003 published report to include the results of AIS interference as it relates to data technologies operating in the VPC spectrum.*

InCode took a two-prong approach to this investigation by evaluating the theoretical makeup and derivation of the interference and by establishing an in-lab study to validate the two distinct types of interference. The first type of interference focused on the occurrence of a MariTEL VPC shore station infrastructure (VPC BS) into an ITU-R 1371-1 AIS shore station (AIS BS) operating in "high seas" simplex mode using international Channels 87B and 88B. The second type of interference investigated focused on an ITU-R 1371 AIS ship station (AIS MS), or AIS BS since they operate in the same simplex frequency, transmitting in the proximity to a MariTEL ship station (VPC MS) using MariTEL's VPC spectrum that encapsulates the AIS 1 and 2 international channel assignments.

Section 2.0: Summary

The goal of this section is to provide a high level summary of the test results detailed in this document.

2.1 VPC Base Station to AIS Base Station Interference

The VPC BS to AIS BS interference will be discussed first. InCode examined the interference from a theoretical and measured perspective. InCode's Shared Site Interference (SSI) Analysis software examined the transmitter noise induced from a VPC BS into an AIS BS. The levels showed a significant amount of transmitter noise injected into the AIS BS receiver. The details of the SSI study can be found in the Appendix. The key point of the SSI analysis indicated that a –121 dB transmitter noise margin reached the AIS BS receiver with a level of susceptibility at the antenna spaced 25 kHz away from the AIS center-frequency's simplex channel. The out of band energy in the AIS BS receiver path from the offending VPC BS transmitter can only be reduced through additional attenuation of the signal between the offending VPC transmitter and the AIS receiver. This would mean using free space loss and / or geographic separation to achieve necessary attenuation.

InCode validated the theoretical interference by establishing an AIS mobile-to-base network in Maritel's lab and simulating the interfering VPC signal using IEC 61993-2 testing criteria through a signal generator into a closed system using a combiner and properly attenuated signals. It can be noted that the IEC 61993-2 test provided a 3 kHz modulated offending signal that is very similar in waveform to the MariTEL SEA 157M VHF analog FM radio at normal excitation. Upon completion of the testing it was noted that an offending VPC signal as weak as –43dBm could effect the AIS base unit under test. It was also noted that due to the significant transmitter energy in the AIS receiver band, the AIS BS would have a network communication failure with a VPC offending signal level of –25dBm at 100 kHz off center-frequency of the AIS receive channel. Diagram 3 highlights these variances in the Results Section of this report to show the outcome of the tests performed.

To summarize, the AIS BS was susceptible to VPC BS interference due to the Simplex AIS operations use of International AIS Channels 87B and 88B in the VPC shore side channel band. This interference occurs because VPC duplex operation transmits on the shore side of the VPC spectrum band designated as the B band. This B band is inclusive of the internationally designated AIS Channels 87B and 88B. The simplex nature of AIS necessitated the technology to both transmit and receive in the B Band. Normally this transmitter energy, or noise, is dealt with by large frequency separations. In the case of the Marine VHF Public Coast Station Band, the FCC designed this separation to be 4.6MHz through duplex operation. Due to the election of simplex operation by the United States Coast Guard, there is not enough spectrum available (only 175kHz) for separation. InCode was able to demonstrate this through theoretical derivation and the lab testing as part of this report.

Due to the random nature and self aligning characteristics of the AIS 1371 technology it was difficult to determine the exact offending signal level required to interfere with the AIS BS unit to cause a consistent industry standard 80% Packet Success Rate (PSR). However, when the offending VPC signal was increased to drive the AIS BS into communication failure, there is consistency within these limits. In any case, certain generalities can be determined from the outcome of the lab tests, which are backed by theoretical analysis. VPC offending signals that drive an AIS BS beyond reception of 80% PSR will quickly deteriorate its reception of AIS data within a few additional dB (decibels) of VPC offending signal to the AIS communication failure point. AIS's frequency diversity through the use of channels 87B and 88B, only provide a limited improvement (3 dB) if the offending VPC signal is lower in frequency than channel 87B. If Channel 28B were used for the offending VPC BS channel, then it would be only 25 kHz on either side of the AIS channels and would eliminate any improvement from frequency diversity.

2.2 AIS Mobile Station to VPC Mobile Station Interference

The second type of interference investigated is the AIS MS operating in simplex mode on Channels 87B and 88B in near proximity to a VPC MS using MariTEL's VPC encapsulating spectrum.

2.2.1 AIS Mobile Station to VPC Mobile Station Analog Voice Interference

In the original inCode report produced on 10/9/03, inCode reviewed the interference potential from an AIS MS into an analog VPC MS device in near proximity. InCode established a closed RF link network between two SEA 157M VHF radios using the same combiner, attenuators and coax as defined by the previous interference test. An AIS MS was programmed on neighboring channels to simulate the AIS MS interference into a VPC analog MS. This report details the noise components recorded with a voice recording received at the VPC MS. The Results Section shows these different types of interference. The interference is a 26msec noise spike occurring from AIS impulse noise in concert with transmitter noise. The transmitter noise is the same phenomenon as indicated in the first interference case. The difference is that the transmitter noise has an additional component to include Gaussian noise caused by the energy required to complete a 1msec transmitter ramp up time of the AIS time slot. This impulse noise intensifies the interference by causing it to spread at low levels up to several MHz away from the AIS simplex channels. For the purpose of this testing, inCode measure across 25 to 225 kHz to see the effects. What was observed, is a direct correlation between the signal threshold received at the VPC MS radio and the offending signal level required to cause interference. This correlation appears to follow a C/I ratio but that scope of work was not verified for purposes of these tests. Due to the nature of the simplex operation of the AIS, guard bands around these channels and/ or an improvement in the transmitter emission mask of the AIS device could substantially reduce the impact of the transmitter noise and diminish the effect of the spreading caused by the impulse noise.

A matrix was developed showing selected signal levels for both the VPC MS received signal level and the VPC MS received signal level from the offending AIS MS and resulting interference. From reviewing Diagram 8 located in the Results Section, it can be noted that 25 and 50 kHz away from the AIS channels, significant interference occurs even at a relatively strong received signal path to the VPC MS from its BS. At 75 and 100 kHz, significant interference levels result when the VPC RF link moves towards its outer coverage limit thus reducing the coverage radius of the VPC system during the AIS interference transmission. A VPC receive channel greater than 100 kHz from the AIS center frequency received an influence from the impulse noise and thus provided a low level interference with a –30dBm offending signal level from the AIS MS into the VPC MS receiver. A 0dBm offending signal level also provides a strong interferer when the VPC RF link fell below –99dBm at the VPC MS receiver. Both AIS and VPC systems are designed to have large coverage areas in excess of 40 miles and this interference substantially reduces the operational range of a VPC network.

Based on this interference, it can be generalized that a VPC MS will have significant impact to its operation every time the AIS MS transmits a message on a time slot. Because this interference is transmitter noise coupled with impulse noise it will require a significant amount of attenuation to greatly reduce the effects of this interference. The interference impact was found to occur across the entire MariTEL spectrum band in varying degrees based on the VPC MS received RF link from the VPC BS and the intensity of the AIS offending transmission level as received by the VPC MS.

2.2.2 AIS Mobile Station to VPC Mobile Station Digital Data Interference

The addendum to this report focused on the inclusion of AIS MS interference as it relates to a VPC digital data radio. MariTEL provided two RF Neulink NL6000 VHF radios for testing. These radios were configured in the identical closed network hardware setup as established for the SEA 157 analog radio tests as previously discussed. The same testing methodology was used with the exception of transmitting a 35 KB text message via a file transfer terminal emulation protocol instead of transmitting phonetically balanced Harvard voice phrases. The Neulink radios differed from the previous test in two ways, they transmitted 6 Watts instead of 1 Watt and their transmit emission mask was based on a 12.5kHz bandwidth. At the time of testing, RF Neulink did not have a 25kHz VHF radio available for MariTEL's use. It is anticipated that a 12.5kHz channel bandwidth would actually be less impacted by the AIS MS interference than a 25kHz channel, based on the interference impact to the receiver across a wider channel bandwidth. The difference in transmit power was normalized by the use of additional attenuation in the closed network.

The Neulink data radios allowed for a comparison of the affects of AIS MS interference on an analog voice device and a digital data radio. The results of the data radio test confirmed the expectation that a digital data radio technology would experience significant interference whenever the AIS MS unit was transmitting. In the digital radio environment, data packets may not be successfully decoded at the VPC MS receiver and therefore impact the data throughput at that instance in time. Depending on the occurrence rate, the VPC data transfer can be completely destroyed and/or have difficulty realigning and overcoming this continual interference. While the NeuLink device contains several operational modes, the most advantageous to MariTEL's requirements is its basic telephony mode, because of its ability to provide the highest throughput over an RF channel. For the purposes of the tests performed, the basic telephony mode was chosen so as not to influence the manipulation of the data through error correction or other means that could significantly reduce the data throughput of the device under test. It can also be noted that error correction techniques such as Forward Error Correction (FEC) codes can be used to overcome low environmental noise conditions. These techniques however can prove to be costly to deploy from a data throughput perspective and become largely ineffective in a high noise environment. It is imperative to make sure that the RF channels in use experience low environmental noise conditions, by limiting the reuse of spectrum and eliminating interference conditions. This will allow for the maximization of data throughput and use of the wireless data network.

Wireless Data protocols are typically very sensitive to both environmental and electrical noise. The lab tests performed eliminated the environmental impacts and instead focus solely on the impact of AIS interference. Therefore, the results of similar test in a real-world environment may yield worse results.

Section 3.0: Test Setup

The set up for the lab investigations included two different configurations. Each configuration is depicted and includes the measured losses through the system. The first configuration found in Diagram 1 (VPC BS interference into AIS BS) was established to validate the interference incurred by the AIS BS from the VPC BS. The second configuration found in Diagram 2 (AIS MS interference into VPC MS) validated the interference incurred by the VPC MS from the AIS MS. The second configuration was performed with two technologies using analog FM voice radios and a later series of test performed using the digital data radios.

Both configurations used a leading manufacturer AIS hardware platform. The AIS BS software was loaded onto one of the AIS mobile hardware units to provide the full AIS network functionality for a lab environment and was verified for proper operation by the manufacturer's personnel. The AIS units under test has been certified by both BSH and type accepted by the FCC for operation in the United States and abroad.

3.1 VPC Base Station to AIS Base Station Interference Test Setup

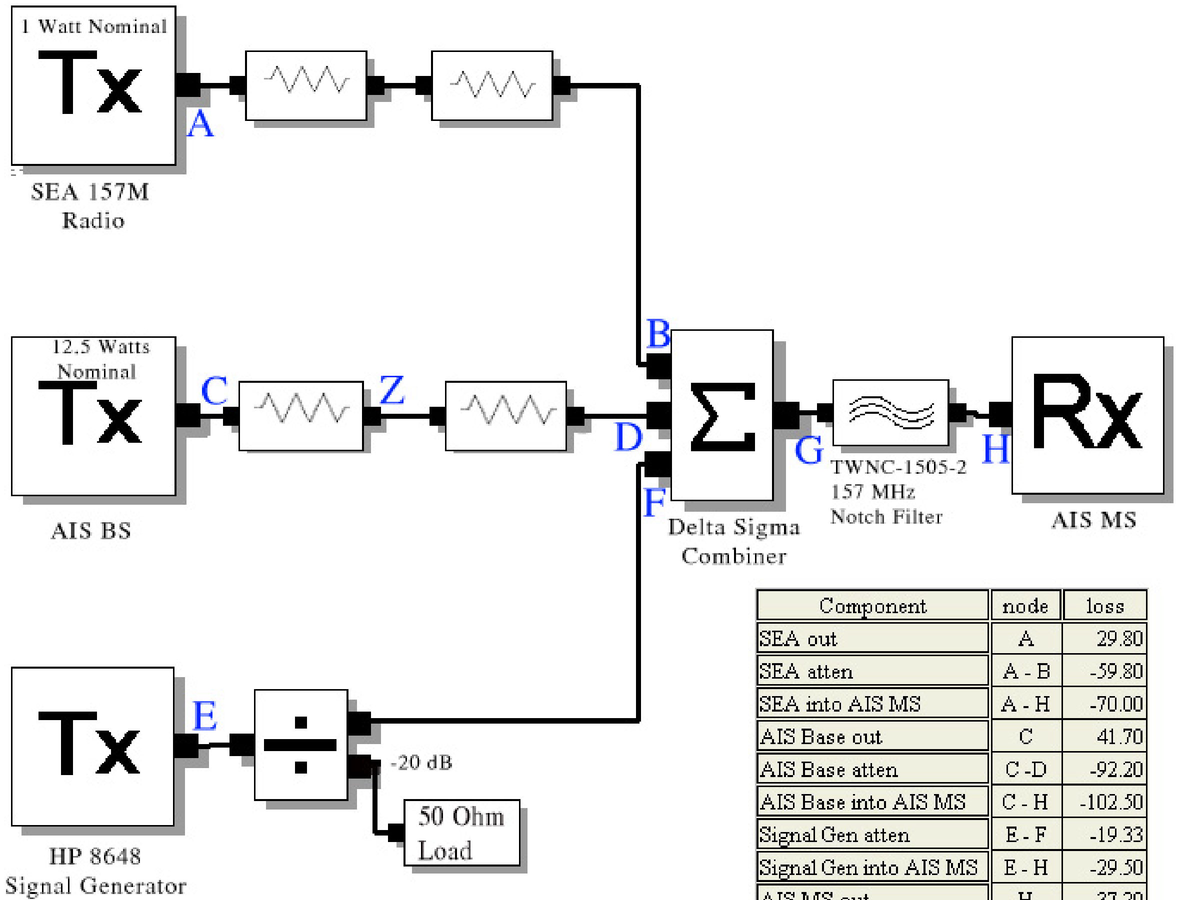
The VPC BS to AIS BS interference configuration test setup simulated the VPC interference by performing to the specifications in the IEC 61993-2 test document. The only exception to the IEC 61993-2 was in the requirement for the AIS unit to be set to –104dBm (3 dB below the ITU established receiver sensitivity of –107dBm) and attain an 80% PSR. The AIS test units supplied would not meet this requirement and a –99dBm receiver threshold attaining an 80% PSR was established for the basis of all testing. InCode used an HP 8648 signal generator to simulate VPC interference. An HP 8560 spectrum analyzer was used to monitor power levels and also view waveforms. A 20dB bi-directional RF coupler was used inline with the spectrum analyzer to keep unwanted energy from overloading its front end. An HP E4416A power meter and HP 9321 probe was also used to have calibrated power levels for the AIS, SEA radios and to verify the signal generator calibrated signal levels.

The VPC BS interference into AIS BS configuration shown in Diagram 1 was the basis for the testing performed to validate the VPC BS TO AIS BS interference. This configuration employed a closed loop network to simulate an open environment, but allowed inCode to control the path losses between the different devices. A Delta Sigma 8 channel hybrid combiner was used to provide the means to combine the AIS MS to AIS BS link and to allow the offending simulated VPC BS interferer to reach the AIS BS. All power levels were verified with both the spectrum analyzer and the power meter. Load bank attenuators were measured through a known calibrated signal to determine their loss values and the received signal power level was calculated by summing the loads, transmitter power levels and the cable losses.

The AIS units were programmed to full duplex mode operation and a 157 MHz notch filter was placed inline between the combiner and the AIS MS. Full Duplex operation was used instead of Simplex to allow inCode the ability to isolate the return path of the AIS MS from transmitting unwanted energy back into the test equipment and desensitizing it. The AIS BS was programmed to transmit on 161.975 MHz on a 25 kHz basis. The VPC BS interferer was simulated using an HP 8648 signal generator set to transmit on 161.95 MHz center frequency with 3 kHz FM modulation as described in the IEC-61993-2 test documentation. The AIS BS transmitted an AIS message at an established interval to the AIS MS. The AIS MS's software verified the proper receipt of the packets transmitted. Several hundred packets were sent per test and the PSR was calculated by taking the difference of the packets received at the AIS MS from the packets sent from the AIS BS over the total packets sent. The AIS link was verified between every test to make sure the AIS units were in proper working order and attained at least 80% PSR without any outside influence on them. This assured that when a the AIS units had a communication under a certain interfering level that they would still operating properly for the next test.

Several different scenarios were run and the results of these tests can be seen in the Results Section under Diagram 3. Primarily the AIS units were set to only transmit on one frequency instead of alternating between 87B and 88B. The purpose for this was to better validate the interference at specified channel spacing under certain conditions. These test conditions included varying the received AIS mobile power from –99dBm to –75dBm to show different performance with weaker or stronger AIS RF link. Also measurements that included both 80% PSR and complete AIS network transmission failure due to VPC interference were run. As stated in the Summary section, the random nature of the AIS technology as it relates to the PSR calculation made it difficult to achieve consistent received signal strength correlations with every test ran. The complete AIS transmission failure point measurement was consistent however. A test run was also performed to include AIS operation on Channels 87B and 88B to validate the ability of the technologies frequency diversity to improve the single AIS frequency test. During this run the VPC interfering frequency was not placed between the two channels on channel 28B but instead deployed on channels 27B and below to provide the adequate channel spacing.

VPC to AIS Interference Test Setup



Component	node	loss
SEA out	A	29.80
SEA atten	A - B	-59.80
SEA into AIS MS	A - H	-70.00
AIS Base out	C	41.70
AIS Base atten	C -D	-92.20
AIS Base into AIS MS	C - H	-102.50
Signal Gen atten	E - F	-19.33
Signal Gen into AIS MS	E - H	-29.50
AIS MS out	H	37.20
AIS MS atten	H - G	-54.80
AIS MS into Gen	H - E	-65.20
Combiner loss	G - D	-9.80

Diagram 1: VPC BS interference into AIS BS

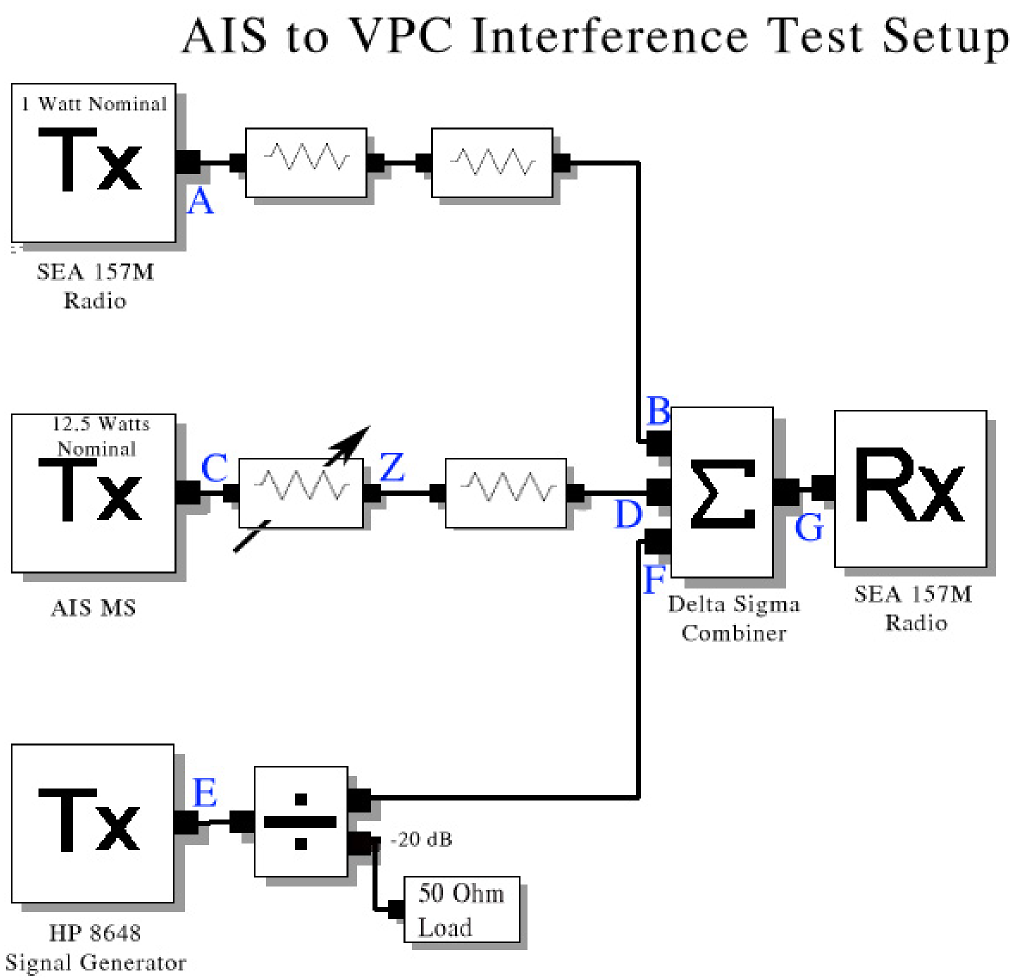


Diagram 2: AIS MS interference into VPC MS

3.2 AIS Mobile Station to VPC Mobile Station Test Setup

The AIS MS to VPC MS interference configuration test setup can be found in Diagram 2. This diagram depicts MariTEL SEA 157M radios. These radios were used for the first series of tests in this configuration that evaluated AIS MS interference as it relates to FM analog voice operated MS devices in the VPC spectrum band. A second series of test were performed using RF Neulink's NL 6000 digital data VHF radios and used the identical closed network hardware configuration with the exception of replacing the SEA 157 radios. When discussing the test setup for the RF Neulink equipment, just assume that the NL6000 replaced the SEA 157M radios. All of the same hardware and test equipment were used for both of these configurations, as was used in the BS interference configuration test setups as described in the previous section. The main difference in the MS interference configuration is that a SEA 157 radio replaced the AIS MS behind the combiner and the notch filter was not needed for this exercise. The configuration also shows the AIS MS was moved forward of the combiner. For purposes of the test, the AIS BS was used to simulate the AIS MS due to the security restrictions limiting inCode's ability to program the unit and forced it to send AIS messages at predetermined intervals for which the AIS BS software has the ability to do. This change does not effect the AIS simulated operation since both units can operate in either a BS or MS mode and makes no difference from an RF perspective.

For the purpose of the MS interference testing, the goal was to have messages sent from the VPC BS to the VPC MS while observing and measuring the impact caused by the AIS MS interference from AIS transmissions on the neighboring channels. This was accomplished by two different means regarding the analog and data radio formats.

3.2.1 AIS Mobile Station to VPC Mobile Station Analog Voice Test Setup

For the SEA 157M analog radios, prerecorded Harvard phonetically balanced phrases were injected into the microphone circuit of the simulated BS radio and were sent across the VPC RF link to simulate conversations and to audibly measure the interference produced by the AIS MS into the VPC MS. The other SEA 157 (simulated MS) radio's audio circuit was tapped to record the interference produced. The purpose of simulating conversations was to provide a means to uniformly reproduce the messaging. Diagrams 4-7 in the Results Sections show a typical recorded output from the SEA 157 radio.

The SEA 157 radios were actually operated in Simplex mode using channel 27A or 157.35 MHz. The first SEA was continually keyed and the Harvard phrases were played across the microphone circuit. The second SEA 157 radio received the messages on the same frequency and the resultant audio output was recorded. The AIS MS was programmed to transmit intermittent AIS single-slot messages at approximately 10-second intervals to simulate the live AIS marine environment. This interference study represents the minimal impact of single-slot messages rather than considering the impact of 2-5 slot AIS messages that would transmit incrementally longer messages based on the number of slots. The AIS MS center frequency was set to Channel 87A or 157.375 MHz. This setup would simulate the exact RF effect of having an AIS MS operating on channel 87B interfering with an full duplex operation VPC MS receiving a transmission from its VPC BS network on Channel 27B.

3.2.2 AIS Mobile Station to VPC Mobile Station Digital Data Test Setup

For the RF Neulink NL 6000 digital data radios, a different means of transmitting messages occurred. The Neulink radios sent a 35 KB text file from the VPC BS to the MS using a 12.5kHz RF link via the Zmodem hyper-terminal emulation software platform. The NL6000 narrowband (12.5 kHz) radios are FCC type accepted data devices for use on VHF Part 90 spectrum. FCC type acceptance number for the data units under test was 11k0f1d (also available is a 16k0f1d device, which was not tested). Once the test file was sent a throughput measurement was observed from the Zmodem software and recorded. A minimum of five successive throughput measurements were recorded and averaged for each data point. The summary of this data can be found in the Results Section of this report.

Wireless data communication links utilize error checking and recovery mechanisms to insure data transmissions are received without error. Typically error detection and re-transmission is used in multiple phases of the communication link. For example, Cyclic Redundancy Check

(CRC) and re-transmission is mostly used within the data hardware devices while the software (or application) also detects and re-transmits data errors. The reason for multiple error detecting and re-transmission schemes is to improve throughput. Detection and re-transmission of an error within the data device (via a CRC) can detect and correct many errors solely within the hardware device (or link layer). Software (of the application layer) corrects errors that are either not detected or cannot be corrected by CRC methods. Software error recovery can take 5–10 seconds as compared with hardware recovery, which can take less than 1 second. These facts explain how data transmissions, in typically the same conditions, can have very different throughput. For example, a bit error in the packet header requires software error recovery whereas a similar bit error in the data part of the packet can often be corrected with the CRC recovery process. In these tests performed, the NeuLink device was configured to provide hardware CRC and the Zmodem software platform provided the software checking.

Section 4.0: Results

This section provides an overview of the outputs measured during the testing performed.

4.1 VPC Base Station to AIS Base Station Results Summary

For the VPC BS to AIS BS interference, a graph depicted in Diagram 3 below shows the relationship between the AIS BS received signal level from the AIS MS and its ability to receive AIS messages successfully at the 80% PSR or to full AIS transmission communication failure. The graph shows three scenarios where the AIS MS was received at the AIS BS with –75, -93 and –99dBm signal level where the AIS messages failed due to VPC interference. These three scenarios only used one AIS frequency to show the effect of varying the VPC interferer to specified channel spacing off of the AIS center frequency. The fourth and fifth scenarios show a stronger received signal level of –75dBm at the AIS BS from its MS and the 80% PSR with an injected VPC signal level. The level of the offending VPC signal as received by the AIS BS is shown on the vertical axis (left hand column). The only difference between the two scenarios is that the fourth scenario used only channel 87B for its transmissions and the fifth scenario varied between channels 87B and 88B.

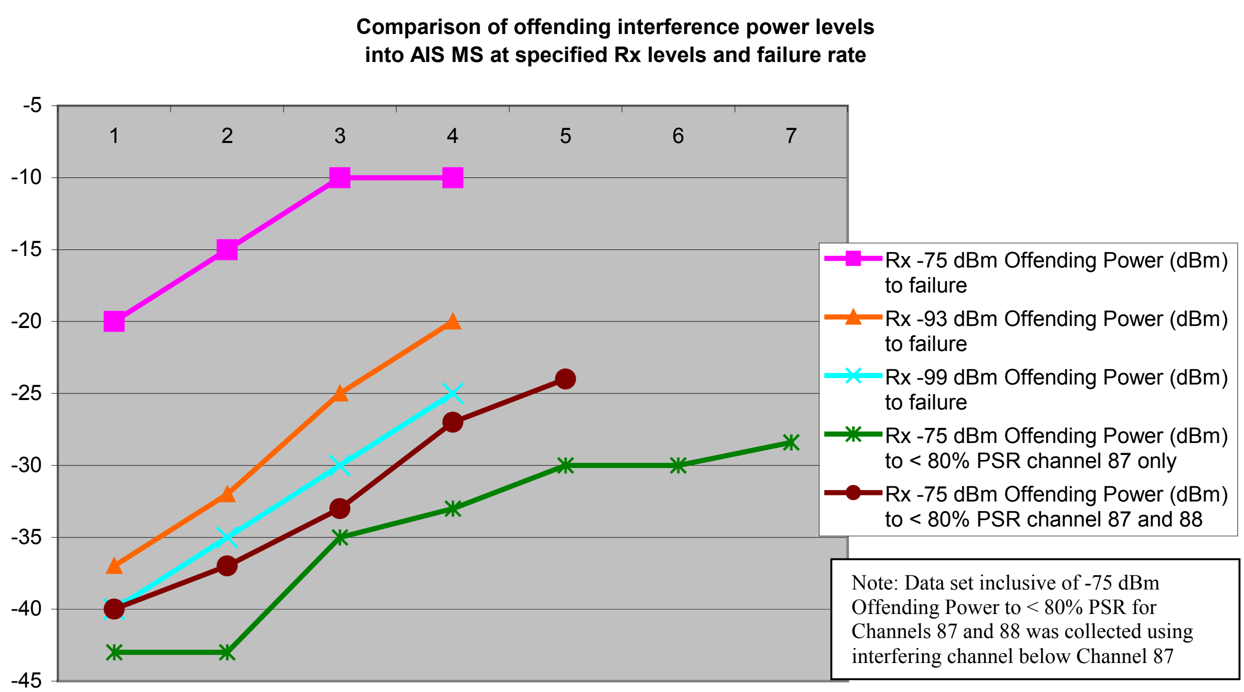


Diagram 3: VPC BS offending levels VS channel spacing @ AIS PSR / failure limits

4.2 AIS Mobile Station to VPC Mobile Station Results Summary

This portion of the Results Section is broken into two areas that represent two varying types of technology. The first area discussed will cover a VPC analog voice radio systems represented by the use of SEA 157M radios. The second area discussed shall cover VPC digital data radio systems represented by RF Neulink's NL6000 narrowband radios (see setup for further description).

4.2.1 AIS Mobile Station to VPC Mobile Station Analog Voice Interference

For the AIS MS to VPC analog voice MS interference, Diagrams 4-7 depicts the measured results of the interference as recorded at the audio circuit of the SEA 157 radio. The difference between Diagrams 4, 5 and 6 are the intensity of the AIS interference recorded. Diagram 4 shows a "high" level of interference. This can be seen by the solid bar appearing in the highlighted red oval on the right hand side of the audio waveform clip. The audio clip shows intensity on the vertical axis and time domain on the horizontal axis. It is very intense and its average level exceeds all of the peaks in the voice waveforms as seen to its left. These voice waveforms correspond to the Harvard phrases sent from the originating SEA 157 radio. The difference between Diagrams 5 and 6 is they have a reduced intensity to show a "medium" and "low" level of AIS interference. The AIS interference for these two diagrams is also highlighted in a red oval. The AIS interference can be seen as a shorter bar with some variance in intensity but below the level of the voice conversation waveforms. Diagram 6 AIS interference is low compared to the voice waveforms. Diagram 7 shows a zoom in on the time intervals so you can see the 26msec AIS timeslot message transmission and its initial 1msec ramp up and ending 1msec ramp down. These waveform diagrams show the substantial energy levels recorded during the testing.

Diagram 8 indicates a summary table of all of the measure AIS MS interference into the VPC MS audio clips. The table in the diagram is organized by 25 kHz channels spaced increasingly further away from the AIS MS center frequency to include all tests performed. Each 25 kHz channel shows the relative strength of the AIS MS interference by category. Each category was broken down in four types: VL, L, M and H. These stand for "very low', "low", "medium" and "high" levels of interference. The rows correspond to the AIS MS received signal at the VPC MS in "dBm". Three levels were measured during the tests. These levels were –60, -30 and 0dBm. This would correspond to a approximately a distance of the AIS MS into the VPC MS of 15 miles, 0.5 miles and 100' respectively using straight free space calculations. This distance would be the distance required to isolate the AIS MS from the VPC MS to greatly reduce the interference level to an acceptable rate. The rows of each group indicate the VPC MS received signal level from its VPC BS transmission. There were four levels measure and they are: -30, -60, -90 and –105dBm. These levels would correspond to an approximate geographic spacing requirement of: 0.9, 25, 38 and 45 miles respectively. These distances are estimates that take into account free space loss, fading and other design characteristics required to design a VPC network. These distances would be required to reduce the AIS interference to an acceptable level using only distance as an attenuating factor.

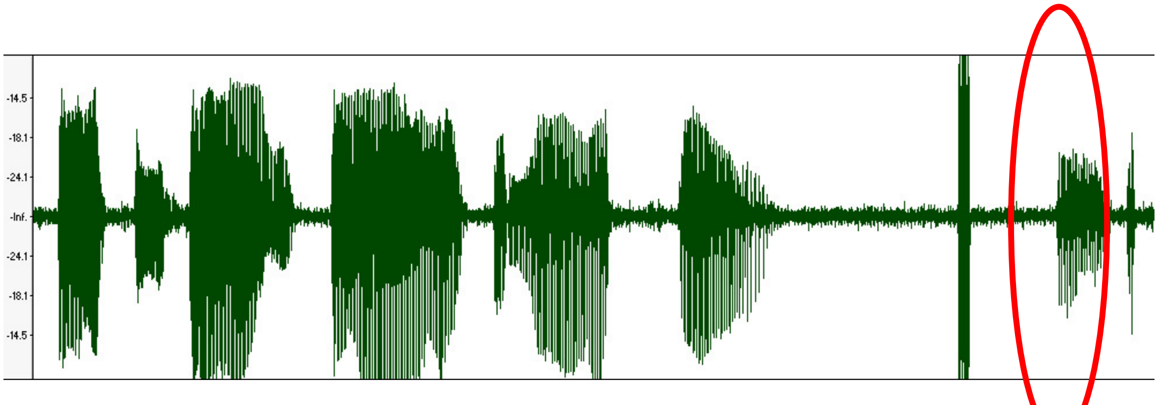


Diagram 4: AIS MS high level interference recorded from VPC MS radio

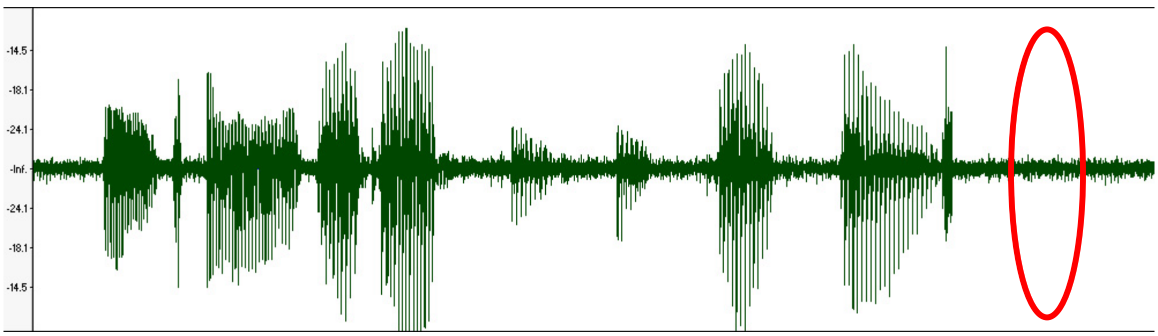


Diagram 5: AIS MS medium level interference recorded from VPC MS radio

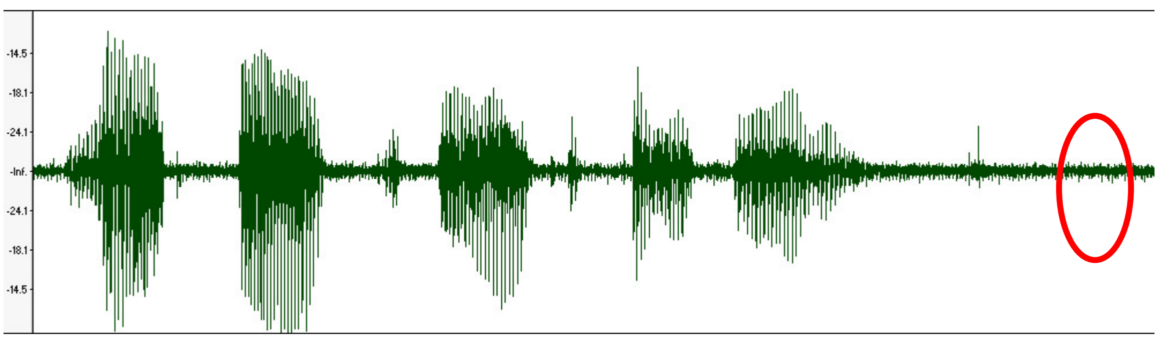


Diagram 6: AIS MS low level interference recorded from VPC MS radio

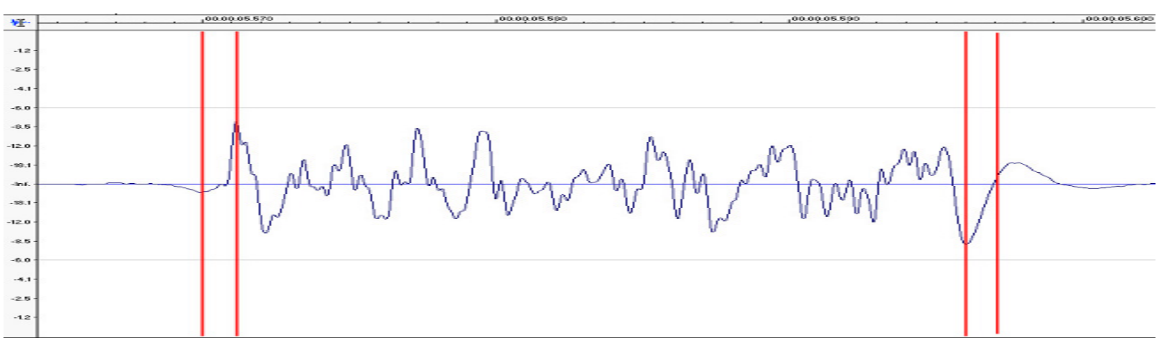


Diagram 7: Detailed view of AIS MS interference recorded from VPC MS radio

25 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	VL	VL
0.5	-30	--	--	M	H
100'	0	VL	H	H	H
	Miles	0.9	25	38	45

50 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	--	--
0.5	-30	--	--	M	H
100'	0	VL	M	H	H
	Miles	0.9	25	38	45

75 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	--	--
0.5	-30	--	--	L	H
100'	0	VL	L	H	H
	Miles	0.9	25	38	45

100 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	--	--
0.5	-30	--	--	L	H
100'	0	VL	VL	H	H
	Miles	0.9	25	38	45

125 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	--	--
0.5	-30	--	--	VL	L
100'	0	VL	VL	H	H
	Miles	0.9	25	38	45

225 kHz Channel Spacing

Miles	dBm	-30	-60	-99	-105
15	-60	--	--	--	--
0.5	-30	--	--	VL	L
100'	0	VL	VL	H	H
	Miles	0.9	25	38	45

AIS Interference Level

VL	Very Low
L	Low
M	Medium
H	High

Diagram 8: Summary of AIS MS in VPC MS Interference

4.2.2 AIS Mobile Station to VPC Mobile Station Digital Data Interference

For the AIS MS to VPC digital data MS interference, Diagram 9 indicates a graphical summary of the measured AIS MS interference into the VPC MS digital data radio. The graph in Diagram 9 provides a summary of the measured data throughput for the variable metrics of: channel spacing away from the AIS interferer and the VPC BS signal level measured at the VPC MS for a fixed interfering AIS MS signal threshold into the VPC MS. The fixed AIS MS interfering level received at the VPC MS and the VPC BS received signal level at the VPC MS were the same levels used for the VPC MS analog voice tests with the addition of –45dBm VPC BS signal received at the VPC MS data receiver. A benchmark test was also added that removed the AIS MS interferer to indicate that the VPC MS data radio was operating at full data throughput periodically throughout the testing process. As can be seen from the results of this data, when the AIS MS interference was stronger than –60dBm, the VPC MS data radio was severely affected at least on one adjacent channel from the AIS MS. When the AIS MS interference was at –30dBm or stronger, 5 channels away from the AIS MS center frequency were severely affected. At 0dBm or stronger, the entire MariTEL spectrum was severely affected rendering the VPC MS throughput reduced by 50%! These AIS MS interfering signal thresholds correspond to distances approximately: 15 miles, 0.5 miles and 100' respectively between the AIS MS and the VPC MS using straight free space calculations. This distance would be required to isolate the AIS MS from the VPC MS to greatly reduce the interference level to an acceptable data throughput rate. For purposes of this test full data throughput was 8500 bps. 7500 bps was deemed marginal acceptable throughput and 7000 bps was deemed unacceptable data throughput based on a reduction of greater than 15% data throughput.

Diagrams 10,11 and 12 show the effects of interference by traditional Public Safety digital radio and analog Part 80 or Part 90 VHF radios. The same tests were ran but substituting the AIS MS for a Motorola XTS5000 P25 Public Safety VHF radio in both a narrowband and wideband (12.5kHz and 25kHz transmission bandwidth) and a SEA 157M analog radio. As you can see from reviewing Diagrams 10 and 11 that the 25kHz channel bandwidth interferer either digital or analog had primarily a transmitter power component caused by too much transmit energy bleeding into the receiver the VPC MS. When the interferer was in the –40dBm range a VPC BS received signal level of –90dBm or weaker measured at the VPC MS was required to cause interruption of data throughput for the VPC MS. For signal strengths greater than –90dBm or interfering levels weaker than –10dBm causes little or no effect on the VPC MS data transmission. Diagram 12 showed a reduced effect due to the tighter transmission bandwidth of the Motorola radio when set to 12.5kHz.

AIS Interference to Data Channel Under Varying Conditions

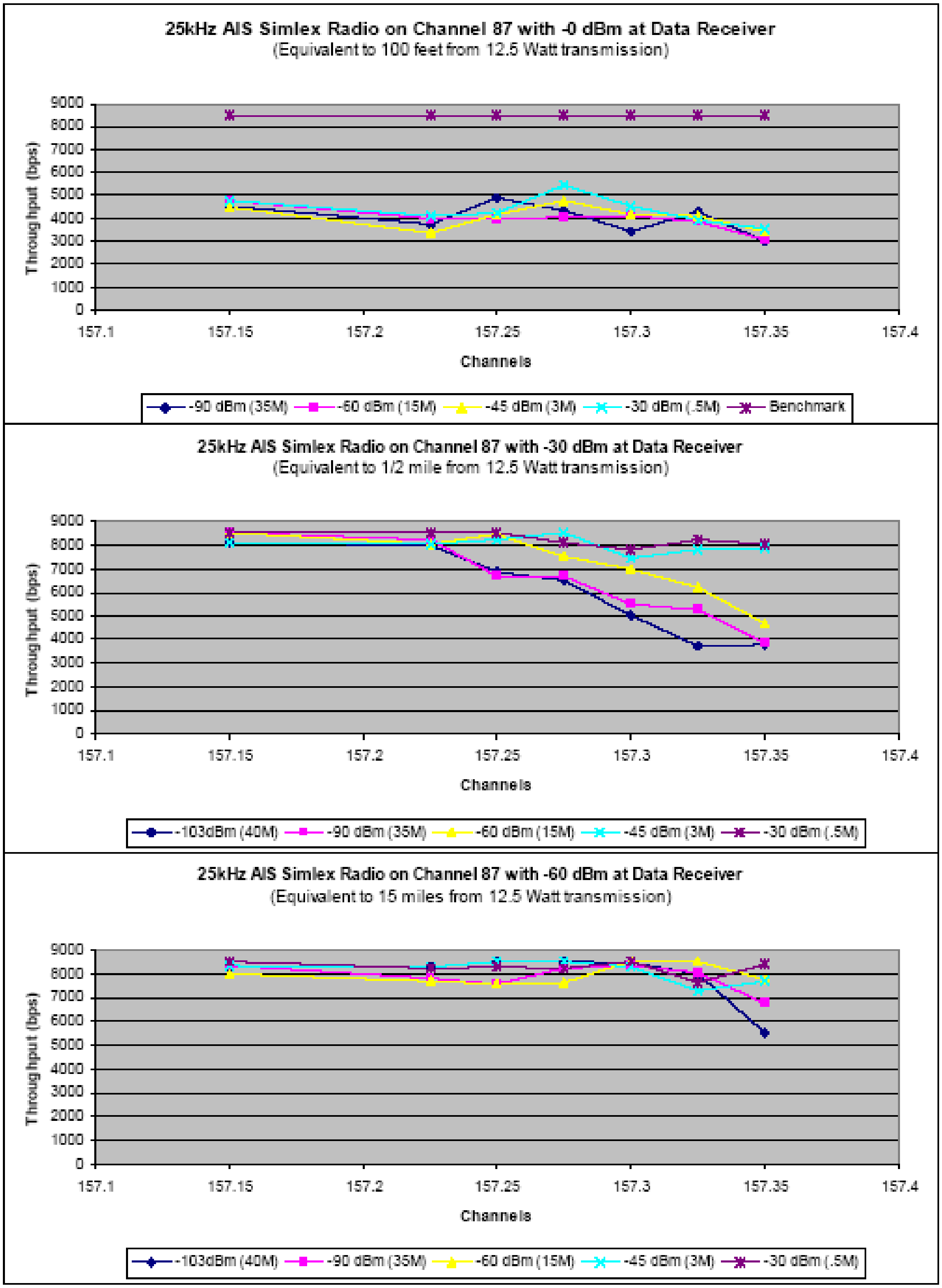


Diagram 9: AIS MS interference into VPC digital data MS

Analogue Radio Interference to Data Channel Under Varying Conditions

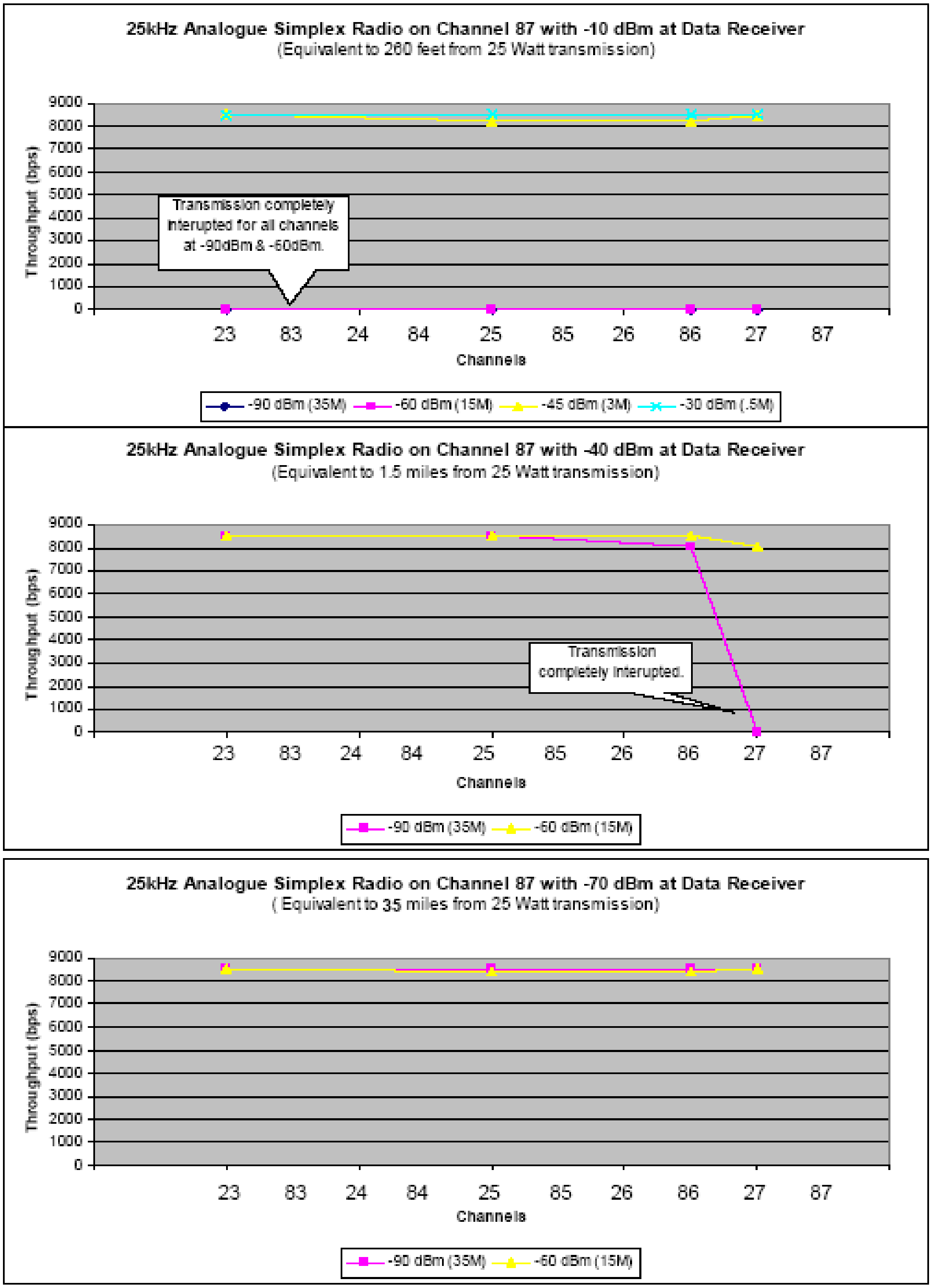


Diagram 10: VHF analog radio interference into VPC digital data MS

WB Digital Radio Interference to Data Channel Under Varying Conditions

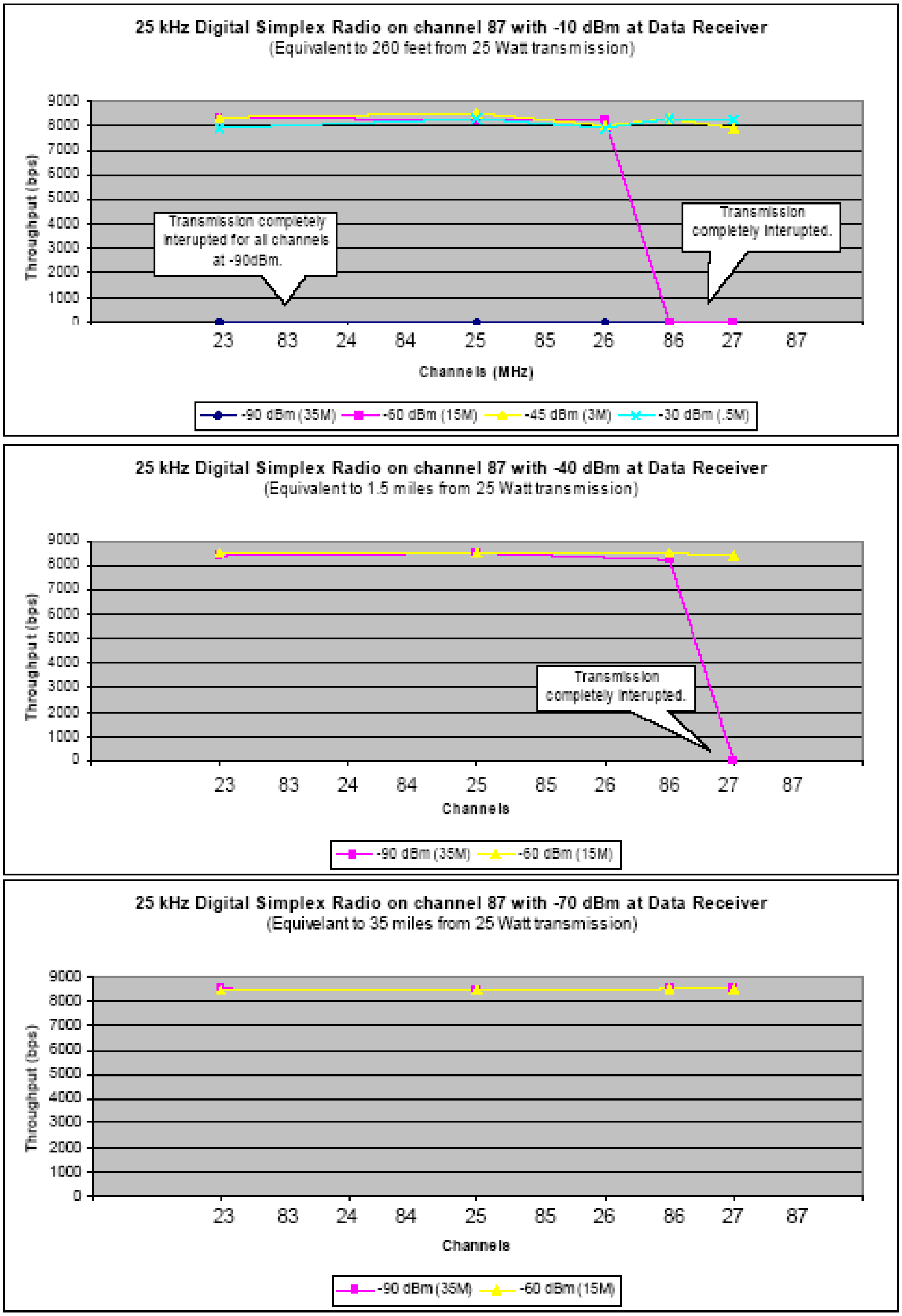


Diagram 11: 25kHz Public Safety radio interference into VPC digital data MS

NB Digital Radio Interference to Data Channel Under Varying Conditions

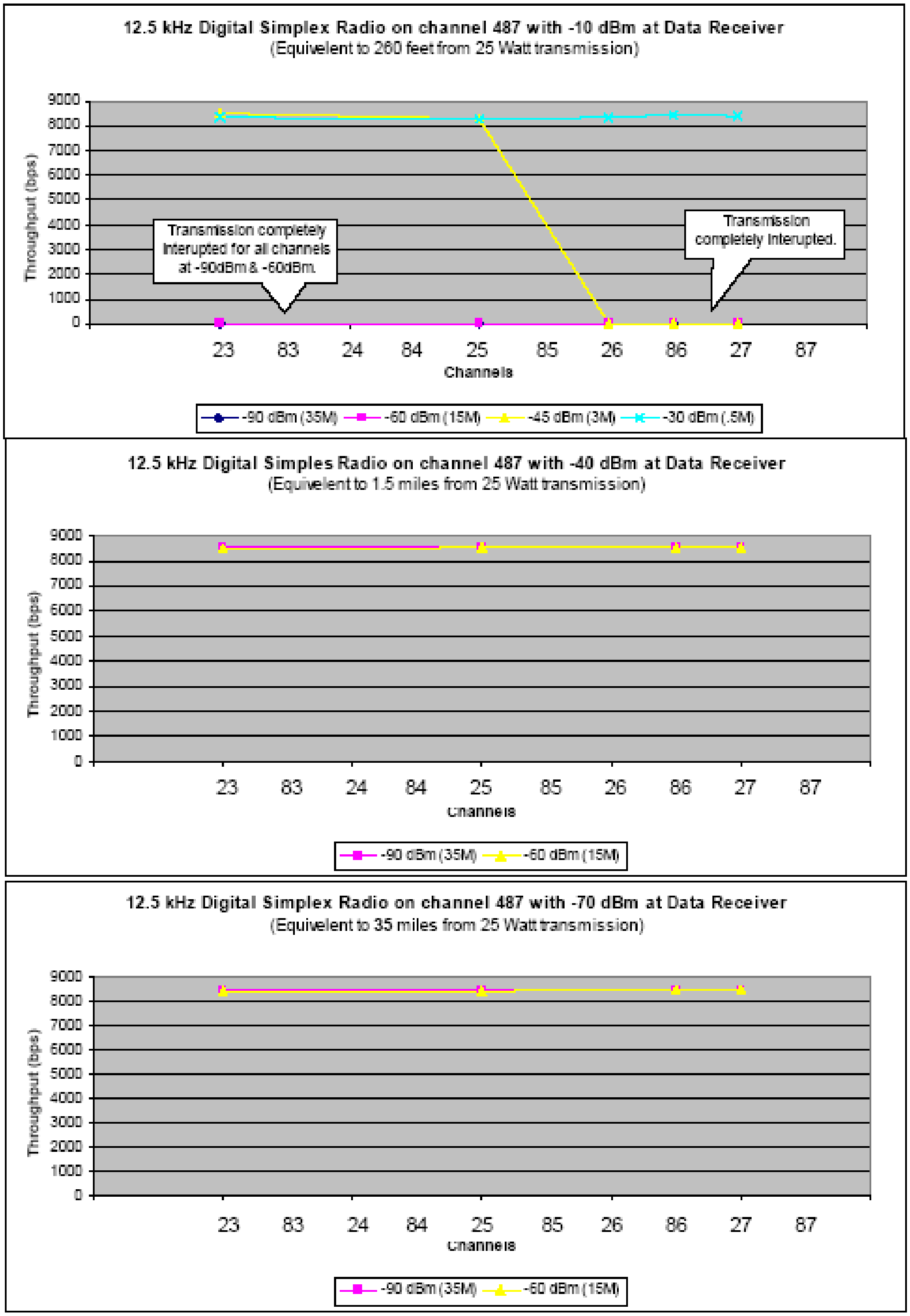


Diagram 12: 12.5kHz Public Safety radio interference into VPC digital data MS

Section 5.0: Appendix of Theoretical Analysis

5.1 Analysis Summary

The results of this analysis indicate the distinct probability of interference problems from adjacent channels to the AIS system from VPC radios operating in the vicinity of the AIS transponders. Reciprocally, the VPC radios will suffer from interference from the AIS system on the ship borne unit. The level of interference indicated suggests the need of 15 miles or greater horizontal separation. Obtaining enough vertical separation may be impractical due to the severity of transmitter noise interference levels identified. The implementation of non traditional filtering techniques may be required to further facilitate VPC and AIS use in the same spectrum. Without these modifications to the AIS device, the interference from adjacent channels will severely hamper the ability of the AIS system to “listen” to boats in the open seas and could very well destroy operations all together. Further, without modifications to the AIS transmitter characteristics, data communications with AIS equipped ships is not possible and communications with ships within 15 miles of an AIS equipped ship will be impacted per the discussion of this report. Joint planning and implementation is recommended in order to deal with these issues.

5.2 Transmitter Noise Analysis

Transmitter noise is interference caused by noise generated by a transmitter that falls within a receiver's bandwidth. This noise level is compared with the receiver's susceptibility. Receiver susceptibility is determined by calculating the equivalent noise floor of the receiver system. This is based on the sensitivity of the receiver and the modulation scheme. For this analysis, susceptibility is considered to be 6 dB below the noise floor. The analysis predicts the transmitter power level in the receiver bandwidth at the receive frequency. The difference between the receiver susceptibility and the predicted interfering power level is called the noise margin. If the noise margin is positive, the number represents the margin before interference occurs. If the noise margin is negative, the amount represents the level of improvement in isolation required between the transmitter and receiver. The system also accumulates the effects of all transmitters on a receiver at a site. The levels in figure 5.2 show the predicted worst-case transmitter noise margin between receivers and transmitters at the site.

TX System	**TX (MHz)**	**RX System**	**RX (MHz)**	**N_{TX} (dBm)**	**$L_{TX\text{-}Ant}$ (dB)**	**$L_{Ant\text{-}Ant}$ (dB)**	**$N_{at\ Ant}$ (dBm)**	**$S_{at\ Ant}$ (dBm)**	**N_{Margin} (dB)**
VPC 25k	161.9625	AIS 1371	161.975	47.9	2.6	22.0	23.3	-132.6	-155.9
AIS 1371	161.975	VPC 25k	161.9625	58.0	2.6	22.0	33.4	-132.6	-166.0
VPC 25k	161.95	AIS 1371	161.975	15.8	4.5	22.0	-10.7	-132.6	-121.9
AIS 1371	161.975	VPC 25k	161.95	58.0	4.5	22.0	31.5	-132.6	-164.1
VPC 25k	161.9375	AIS 1371	161.975	6.9	6.3	22.0	-21.5	-132.6	-111.1
AIS 1371	161.975	VPC 25k	161.9375	54.3	6.3	22.0	25.9	-132.6	-158.5
VPC 25k	161.925	AIS 1371	161.975	-2.1	8.2	22.0	-32.3	-132.6	-100.2
AIS 1371	161.975	VPC 25k	161.925	26.0	8.2	22.0	-4.2	-132.6	-128.4

Table 5.2.1 – VPC Radio on 25 kHz Channel vs. AIS 1371 Radio Transmitter Noise

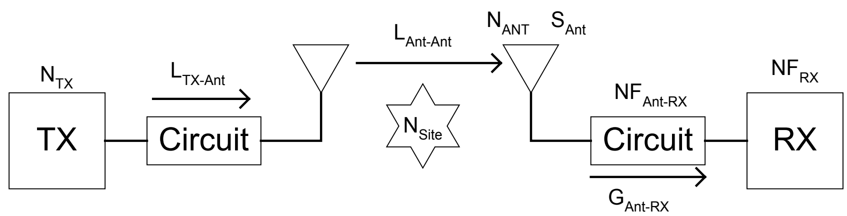
TX System	**TX (MHz)**	**RX System**	**RX (MHz)**	**N_{TX} (dBm)**	**$L_{TX\text{-}Ant}$ (dB)**	**$L_{Ant\text{-}Ant}$ (dB)**	**$N_{at\ Ant}$ (dBm)**	**$S_{at\ Ant}$ (dBm)**	**N_{Margin} (dB)**
VPC 12.5k	161.9625	AIS 1371	161.975	7.0	2.6	22.0	-17.6	-132.6	-114.9
AIS 1371	161.975	VPC 12.5k	161.9625	55.5	2.6	22.0	30.9	-132.1	-163.0
VPC 12.5k	161.95	AIS 1371	161.975	-3.4	4.5	22.0	-29.8	-132.6	-102.7
AIS 1371	161.975	VPC 12.5k	161.95	55.5	4.5	22.0	29.0	-132.1	-161.1
VPC 12.5k	161.9375	AIS 1371	161.975	-13.3	6.3	22.0	-41.7	-132.6	-90.9
AIS 1371	161.975	VPC 12.5k	161.9375	51.8	6.3	22.0	23.4	-132.1	-155.5
VPC 12.5k	161.925	AIS 1371	161.975	-23.2	8.2	22.0	-53.5	-132.6	-79.1
AIS 1371	161.975	VPC 12.5k	161.925	23.6	8.2	22.0	-6.7	-132.1	-125.4

Table 5.2.2 – VPC Radio on 12.5 kHz Channel vs. AIS 1371 Radio Transmitter Noise

Figure 5.2 Transmitter Noise Summary

5.3 Worst Case Transmitter Noise Example Calculation

The worst-case example of transmitter noise is from the transmitter (161.9625 MHz) in the transmit circuit in system 'VPC' to the receiver (161.975 MHz) in system 'AIS'. The transmitter noise margin value of -114.9 dB is calculated using the following method:



Step 1: Calculate transmitter noise at receiver's antenna.

F_{TX}	= 161.9625 MHz	Transmit frequency
F_{RX}	= 161.975 MHz	Receive frequency
BW_{RX}	= 20 kHz	Receiver bandwidth
P_{TX}	= 44.0 dBm	Transmitter power
PSD_{TX}	= -80.0 dBc	Relative power emitted by trans. in receiver band (from transmitter's power spectral density curve)
$L_{TX\text{-}Ant}$	= 2.6 dB	Loss from transmitter to transmitter's antenna at F_{RX}
$L_{Ant\text{-}Ant}$	= 22.0 dB	Antenna (or coupler) isolation at F_{RX}

N_{TXC} — Noise emitted by transmitter in receiver's band relative to carrier

$= PSD_{TX} + 10 \times \log (BW_{RX})$
$= -80.0 + 10 \times \log (20000.0)$
$= -37.0$ dBc

N_{TX} — Noise at transmitter in receiver's band

$= P_{TX} + (N_{TXC})$
$= 44.0 + (-37.0)$
$= 7.0$ dBm

N_{Ant} — Transmitter noise at receiver's antenna

$= N_{TX} - (L_{TX\text{-}Ant} + L_{Ant\text{-}Ant})$
$= 7.0 - (2.6 + 22.0)$
$= -17.6$ dBm

Step 2: Calculate the susceptibility of the receiver at its antenna.

$Sense_{RX}$ = -117.0 dBm	Receiver sensitivity
[C/N] = 18.0 dB	Equivalent carrier-to-noise level for specified receiver sensitivity
NF_{Ant-RX} = 0.5 dB	Equivalent noise figure of sector from antenna (or coupler) to receive input
N_{Site} = 3.6 dBkTB	Site noise from Site Noise curve relative to kTB
G_{Ant-RX} = -0.5 dB	Gain from antenna (or coupler) to receiver

kTB =
$= -174.0 + 10 \times \log(BW_{RX})$
$= -174.0 + 10 \times \log(20000.0)$
$= -131.0$ dBm

Thermal noise in the receiver bandwidth at room temperature.

NF_{RX}
$= Sense_{RX} - [C/N] - (kTB)$
$= -117.0 - 18.0 - (-131.0)$
$= -4.0$ dB

Noise figure of receiver

NF'_{Ant}
$= 10^{(NFAnt\text{-}RX)/10} + [(10^{(NFRX/10)}-1)/ 10^{(GAnt\text{-}RX/10)}]$
$= 10^{(0.5)/10} + [(10^{(-4.0/10)}-1)/ 10^{(-0.5/10)}]$
$= 0.4$

Noise factor at antenna

NF_{Ant}
$= 10 \times \log(NF'_{Ant})$
$= 10 \times \log(0.4)$
$= -3.5$ dB

Noise factor at antenna in decibels

NF_{SysAnt}
$= 10\times\log(10^{(NFAnt / 10)} + 10^{(NSite / 10)})$
$= 10\times\log(10^{(-3.5/10)} + 10^{(3.6/10)})$
$= 4.4$ dB

System noise figure at antenna adds external noise at the site to the internal noise at the antenna.

$S_{RX\ Ant}$
$= kTB + NF_{SysAnt} - 6$
$= -131.0 + 4.4 - 6$
$= -132.6$ dBm

Susceptibility of receiver to interference at receive antenna

Step 3: Calculate the noise margin.

N_{Margin}
$= S_{RX\ Ant} - N_{Ant}$
$= -132.6 - (-17.6)$
$= -114.9$ dB

Margin between noise reaching receive antenna and level of susceptibility at antenna

5.4 Receiver Desensitization Analysis

Receiver desensitization is interference caused by transmitter signals coupling into a receiver and desensitizing the receiver. The leakage power is compared with the receiver's desensitization level. For this analysis, receiver desensitization level is defined as level that degrades the receiver sensitivity by 1 dB. A positive desensitization margin represents the margin before interference occurs. If the desensitization margin is negative, the amount represents the level of improvement in isolation required between the transmitter and receiver at the transmitter frequency. The system also accumulates the effects of all transmitters on a receiver at a site. Receiver Desensitization for this analysis did show scenarios where interference could be an issue. Due to the significant transmitter noise involved the Receiver Desensitization problem is secondary in nature and is not the primary concern.

The levels in figure 5.4 show the predicted worst-case receiver desensitization margin between the receivers and transmitters at the site.

TX System	TX (MHz)	RX System	RX (MHz)	P_{TX} (dBm)	$L_{TX\text{-}Ant}$ (dB)	$L_{Ant\text{-}Ant}$ (dB)	$L_{Ant\text{-}RX}$ (dB)	$P_{at\ RX}$ (dBm)	$D_{at\ RX}$ (dBm)	D_{Margin} (dB)
VPC 25k	161.9625	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	-70.0	-90.7
AIS 1371	161.975	VPC 25k	161.9625	40.0	0.7	22.0	0.5	16.7	-50.0	-66.7
VPC 25k	161.95	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	-20.0	-40.7
AIS 1371	161.975	VPC 25k	161.95	40.0	0.7	22.0	0.5	16.7	-5.0	-21.7
VPC 25k	161.9375	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	25.0	4.3
AIS 1371	161.975	VPC 25k	161.9375	40.0	0.7	22.0	0.5	16.7	25.0	8.3
VPC 25k	161.925	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	30.0	9.3
AIS 1371	161.975	VPC 25k	161.925	40.0	0.7	22.0	0.5	16.7	30.0	13.3

Table 5.4.1 – VPC Radio on 25 kHz Channel vs. AIS 1371 Radio Receiver Desensitization

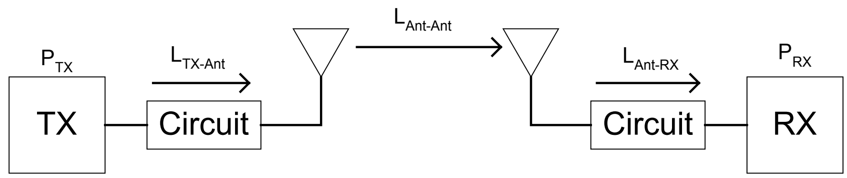
TX System	TX (MHz)	RX System	RX (MHz)	P_{TX} (dBm)	$L_{TX\text{-}Ant}$ (dB)	$L_{Ant\text{-}Ant}$ (dB)	$L_{Ant\text{-}RX}$ (dB)	$P_{at\ RX}$ (dBm)	$D_{at\ RX}$ (dBm)	D_{Margin} (dB)
VPC 12.5k	161.9625	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	-70.0	-90.7
AIS 1371	161.975	VPC 12.5k	161.9625	40.0	0.7	22.0	0.5	16.7	5.0	-11.7
VPC 12.5k	161.95	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	-20.0	-40.7
AIS 1371	161.975	VPC 12.5k	161.95	40.0	0.7	22.0	0.5	16.7	30.0	13.3
VPC 12.5k	161.9375	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	25.0	4.3
AIS 1371	161.975	VPC 12.5k	161.9375	40.0	0.7	22.0	0.5	16.7	30.0	13.3
VPC 12.5k	161.925	AIS 1371	161.975	44.0	0.7	22.0	0.5	20.7	30.0	9.3
AIS 1371	161.975	VPC 12.5k	161.925	40.0	0.7	22.0	0.5	16.7	30.0	13.3

Table 5.4.2 – VPC Radio on 25 kHz Channel vs. AIS 1371 Radio Receiver Desensitization

Figure 5.4 Receiver Desensitization Summary

5.5 Worst Case Receiver Desensitization Example Calculation

The worst-case example of receiver desensitization is from the transmitter (161.9625 MHz) on transmitting circuit in system 'VPC' to the receiver (161.975 MHz) in system 'AIS 1371'.



Step 1: Calculate transmitter power at receiver.

F_{TX} = 161.9625 MHz	Transmit frequency
F_{RX} = 161.975 MHz	Receive frequency
BW_{RX} = 20 kHz	Receiver IF bandwidth (for 25 kHz channel)
P_{TX} = 44.0 dBm	Transmitter power
$L_{TX\text{-}Ant}$ = 0.7 dB	Loss from transmitter to transmitter's antenna at F_{TX}
$L_{Ant\text{-}Ant}$ = 22.0 dB	Antenna (or coupler) isolation at F_{TX}
$L_{Ant\text{-}RX}$ = 0.5 dB	Losses from receiver's antenna to receiver at F_{TX}

P_{RX} — Power emitted by transmitter in transmitter's band reaching receiver

$= P_{TX} - (L_{TX\text{-}Ant} + L_{Ant\text{-}Ant} + L_{Ant\text{-}RX})$

$= 44.0 - (0.7 + 22.0 + 0.5)$

$= 20.7$ dBm

Step 2: Calculate desensitization margin at receiver.

$Dense_{RX}$ = -70.0 dBm — Desensitization level of receiver at F_{TX}. This value is derived from the LNA's power rejection mask curve.

$D_{RX\ Margin}$ — Margin between desensitization level of the receiver and the transmitter power reaching the receiver

$= Dense_{RX} - (P_{RX})$

$= -70.0 - (20.7)$

$= -90.7$ dB